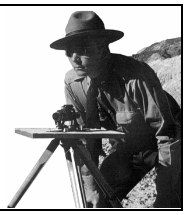
GEOLOGIC RESOURCE MONITORING PARAMETERS

Glacier Fluctuations



Brief Description: Changes in glacier movement, length and volume can exert profound effects on the surrounding environment, for example through sudden melting which can generate catastrophic floods, or surges that trigger rapid advances (in the recent surge of the Bering Glacier, Alaska, as much as 12 km in a 60 day period). Standard parameters include mass balance and the glacier length, which determines the position of the terminus. The location of the terminus and lateral margins of ice and rock glaciers exerts a powerful influence on nearby physical and biological processes. Through a combination of specific balance, cumulative specific balance, accumulation area ratio and equilibrium-line altitude, mass balance reflects the annual difference between net gains (accumulation) and losses (ablation). It may also be important to track changes in the discharge of water from the glacier as indicators of glacier hydrology. Abrupt changes may warn of impending acceleration in melting, cavitation, or destructive flooding.

Significance: Glaciers are highly sensitive, natural, large-scale, representative indicators of the energy balance at the Earth's surface in polar regions and high-altitudes. Their capacity to store water for extended periods exerts significant control on the surface water cycle. The advance and retreat of mountain glaciers creates hazards to nearby human structures and communities through avalanches, slope failure, catastrophic outburst floods from ice and moraine-dammed lakes. Notwithstanding local glacier advances, the length of mountain glaciers and their ice volume has decreased throughout the world during the past century or two, providing strong evidence for climate warming, though there may also be local correlations with decreasing precipitation. It is estimated that the European Alps have lost more than half their ice in the past century

Environment where Applicable: Wherever glaciers and icecaps occur.

Types Of Monitoring Sites: Selected glacier forelands and icecaps strategically located to record climate changes, or liable to rapid advances/retreats that may affect fluvial systems or nearby settlements.

Method of Measurement: Analysis of air photos and high-resolution satellite images, ground surveys. GPS data may be useful in detecting glacial surges and estimating the volume of ice being transferred

Frequency of Measurement: Annually, more frequently where glaciers are surging.

Limitations of Data and Monitoring: The monitoring of continental glaciers, such as the Antarctic and Greenland ice sheets, is a complex matter, and there is no easy technique for detecting volume changes that will affect sea levels. Horizontal advances or retreats of an ice sheet margin may not provide timely information on volume changes, and field studies of mass balance can never adequately cover the entire ice sheet.

Key References:

Hambrey, M. 1994. Glacial environments. London, UCL Press.
Matthews, J.A., 1992. The ecology of recently-deglaciated terrain: a geoecological approach to glacier forelands and primary succession. Cambridge University Press.

Nesje, A. 1996. Geological indicators of rapid environmental change - glacier fluctuations and avalanche activity. In Berger, A.R. & W.J.Iams (eds). Geoindicators: Assessing rapid environmental changes in earth systems:17-32. Rotterdam: A.A. Balkema.

UNEP/GEMS, 1992. Glaciers and the environment. United Nations Environment Programme, Environment Library 9.

Related Environmental and Geological Issues: Glacier melting can sometimes trigger catastrophic flood outbursts (jökulhlaups) from marginal lakes blocked by moraines, though failure of these natural dams may have a variety of other causes. The decreasing capacity of retreating glaciers to store water affects downstream water supply and thus the availability of water for agriculture and human consumption. Glacier forelands newly exposed in front of receding glaciers provide excellent natural laboratories to study plant succession and soil development.

Overall Assessment: Fluctuations in glaciers are among the most sensitive indicators of climatic change. They can be also used as indicators of temperature and precipitation changes that occurred prior to instrumental weather records.

Source: This summary of monitoring parameters has been adapted from the Geoindicator Checklist developed by the International Union of Geological Sciences through its Commission on Geological Sciences for Environmental Planning. Geoindicators include 27 earth system processes and phenomena that are liable to change in less than a century in magnitude, direction, or rate to an extent that may be significant for environmental sustainability and ecological health. Geoindicators were developed as tools to assist in integrated assessments of natural environments and ecosystems, as well as for state-of-the-environment reporting. Some general references useful for many geoindicators are listed here:

Berger, A.R. & W.J.Iams (eds.) 1996. Geoindicators: assessing rapid environmental change in earth systems. Rotterdam: Balkema. The scientific and policy background to geoindicators, including the first formal publication of the geoindicator checklist.

Goudie, A. 1990. Geomorphological techniques. Second Edition. London: Allen & Unwin. A comprehensive review of techniques that have been employed in studies of drainage basins, rivers, hillslopes, glaciers and other landforms.

Gregory, K.J. & D.E.Walling (eds) 1987. Human activity and environmental processes. New York: John Wiley. Precipitation; hydrological, coastal and ocean processes; lacustrine systems; slopes and weathering; river channels; permafrost; land subsidence; soil profiles, erosion and conservation; impacts on vegetation and animals; desertification.

Nuhfer, E.B., R.J.Proctor & P.H.Moser 1993. The citizens' guide to geologic hazards. American Institute for Professional Geologists (7828 Vance Drive, Ste 103, Arvada CO 80003, USA). A very useful summary of a wide range of natural hazards.